2019 Spring Research Symposium
Gustavus Adolphus College, May 3, 2019

Session A: Oral Presentations, Olin Hall 103

1:30 pm

Dopant Concentration Dependence of Crystal Structure Stability and Optical Properties of Luminescent $Ln_x:Y_{x-1}VO_4$ (Ln=Nd, Sm)

Luminescent materials are increasingly important in modern society with applications from light-emitting diodes (LED) and solid-state lasers to fiber-optic amplifiers and medical tools. Many of the materials that are used for these applications are crystalline and host dopant atoms without changing the crystal structure. These systems are referred to as solid solutions. The extent to which dopant atoms can be substituted within the host lattice is determined by the atomic size of the dopant and by how resilient the host lattice is to structural deformation. The functional properties of these materials are closely linked with phase stability and the concentration of substituted dopants. Understanding the stability of these solid solutions through the limits of dopant concentration would allow for easier development of related materials. In this study we synthesized rare-earth doped yttrium orthovanadates with the general formula $Ln_x:Y_{x-1}VO_4$ (Ln=Nd, Sm) with a dopant concentration range from 3-12 mole percent. The phase purity and lattice parameters were determined by powder x-ray diffraction and the emission spectra were taken to investigate trends due to dopant concentration.

Michaela Zachman and Ian Hill
Advisor: Ian Hill, Chemistry

1:45 pm

Laboratory Analysis of Rock Sample Suites from a Mars Rover Simulation, Green River Formation, Utah

The Mars 2020 Rover has a primary mission goal of finding biosignatures. To help improve mission effectiveness, the Geo-Heuristic Operational Strategies Tests (GHOST) aim to test rover decision-making protocols on Earth-analog sites. In 2017, GHOST used a "roverless roving" approach to compare the effectiveness of two traverse methods in biosignature identification at an analog site in Utah. This study focuses on laboratory analysis of samples collected by each traverse team to determine whether traverse strategy results in sample suites that differ substantially in their potential for environmental reconstruction and biosignature identification.

Both the linear and walkabout traverses recovered carbonate samples, and the walkabout traverse additionally collected an organic-rich shale. Samples were characterized via several instruments that might be used to evaluate martian samples. Field and laboratory analyses indicate in a shallow water deposition and subsequent low-temperature diagenesis. At least one carbonate in each sample set has macroscopic features consistent with microbial origin with potential biosignature preservation, and the organic-rich shale sample suggests a possible biosignature as well.

Both traverse methodologies resulted in a sample suite with a high likelihood of biosignature preservation. The walkabout traverse recovered a greater diversity of sample types compared to the linear traverse, providing additional depositional environment information. Our results indicate that a limited sample suite can correctly identify the geology and biosignature potential of a region of interest, and a walkabout traverse provides the opportunity to compare sites prior to sample collection, leading to a more diverse sample suite.

Madison Adams, Julie Bartley, R. Aileen Yingst, Rebecca M. Williams, Linda C. Kah, Michael Lotto, and Michelle E. Minitti
Advisor: Julie Bartley, Geology

2:00 pm	**Low Frequency Sound Waves Effect on Pain Perception Generated by the Cold Pressor Task** The medical community is trying to identify alternative ways to treat chronic pain because the current treatment, opioids, is very addictive (Volkow & Collins, 2017). One viable alternative to medication would be the utilization of low frequency sound wave therapy. Low frequency sound waves have been used to treat a variety of ailments, most commonly chronic and acute pain. There have been many different forms of low frequency sound wave therapy including vibroacoustic therapy, physioacoustic intervention, vibrotactile stimulation, and many others. Due to the many different forms of presentation, it is currently unknown which presentation of sound is the most effective. Low frequency sound waves are thought to reduce pain by simulation of the Pacinian corpuscles or through relaxation effects. This study examined four different presentations of sound, haptic (touch), auditory (hearing), both haptic and auditory, and silence to determine how sound waves affect pain perception (through Pacinian corpuscles or effects of relaxation) and what method of presentation is the most effective. Pain was induced through cold-water immersion (i.e. the cold pressor task) and the duration of time the participant was in the task determined the amount of pain a participant was able to endure. No significant results were found. **Hannah Nolte** Advisor: Mark Kruger, Psychological Science
2:15 pm	**Qualitative and Quantitative Cyclic Voltammetry in Upper Division Chemistry Teaching Labs** Cyclic voltammetry is a technique that measures the change in current of a solution as a chemical species is oxidized or reduced with an applied potential. Recent acquisition of a potentiostat has allowed students to be introduced to experimental electrochemistry and the qualitative and quantitative information that can be determined using cyclic voltammetry. Students in Quantitative Analysis have measured the vitamin C content of fruit juice using this method and students in Inorganic Chemistry will be using this technique to characterize an iron sandwich complex (ferrocene). **Rachel Lund** and Matthew Venzke Advisor: Brian O'Brien, Chemistry
2:30 pm	**Lamina Structure as an Indicator of Stromatolite Biogenicity** Stromatolites are mounds of trapped and bound or precipitated sediments produced by microbes. These mounds become fossils in the sedimentary record, recording some of the oldest fossil evidence for life on Earth; they also form today in several environments. In addition, rover-based work on Mars suggests that the conditions for producing stromatolites were present, if microbial life ever thrived on the planet, and the 2020 Mars rover will actively seek microbial biosignatures. However, because layered structures similar to stromatolites can form abiotically, it is important to establish criteria for recognizing biotic influence in putative stromatolites. Currently, no unambiguous set of criteria can be used to distinguish biogenic lamina structures from abiogenic ones. This study aims to create a list of features that can be used to determine the biogenicity of laminated structures at a scale useful to a rover (on Mars) or to a field geologist (on Earth). We compared three sample types: (1) hot springs stromatolites in which biogenicity is uncertain; (2) biogenic stromatolites that are about 50 million years old; and (3) travertine limestones that are likely abiotic. Mesoscale lamina maps were constructed to characterize lamina thickness, shape, and spatial variability. Synoptic relief, inheritance, lamina thickness, and deformation style are potential morphological

	characteristics that indicate biogenicity. In addition, micro x-ray fluorescence maps were produced to evaluate the degree to which elemental composition relates to lamina origin. Strong elemental signals related to lamina genesis appear to be characteristic of abiotic laminae compared to biogenic structures. **Thais Altenberg-Vaz** Advisor: Julie Bartley, Geology
2:45 pm	**Effect of Rapid Cold-Hardening on Respiration Rates of Mitochondria Isolated from Sarcophaga Bullata** Rapid cold-hardening (RCH) describes the physiological response of insects to swiftly enhance protection against cellular damages associated with cold exposures. Within minutes to hours at a moderately low-temperature, insects undergo physiological changes to drastically increase survival to a subsequent exposure to extreme cold. The induction of RCH is a cellular response and occurs without neural or endocrine inputs. At the cellular level, the RCH induction leads to changes in the membrane composition to increase its fluidity. According to the membrane pacemaker hypothesis, an increase in membrane fluidity promotes a greater rate of cellular metabolism. Because RCH increases the membrane fluidity, I hypothesized that these changes would affect the mitochondria, the powerhouse of the cell, and its respiration rates. Consequently, in the present study, respiration rates of the mitochondria isolated from the thorax of the flesh fly were examined with or without the RCH induction. At the organismal level, survival of the flesh fly to -7°C for 2 h was significantly increased by RCH at 5°C for 2 h from 37.0% ± 7.0 to 97% ± 3.4. However, the RCH induction did not significantly affect the rates of mitochondrial respiration or the respiratory control ratio (RCR). Acclimation that takes place over the course of days to weeks generally leads to some changes in the mitochondrial properties. While acclimation and RCH share some underlying mechanisms, they are a distinctly different set of physiological responses. Therefore, future study would systematically compare changes manifested at the level of the mitochondria in response to acclimation and RCH response. **Alyssa Welle** Advisor: Yuta Kawarasaki, Biology
3:15 pm	**Estimating Vigor of Echinacea Angustifolia Relative to its Non-Native Congener E. pallida and Their Hybrids in a Fragmented Prairie Habitat** Introduced plants can alter population dynamics of native congeners and facilitate change to community structure. This is exacerbated if the introduced species and its native congener are able to form hybrids. The long-lived tetraploid forb Echinacea pallida was introduced to severely fragmented prairie in Douglas County, MN, where it has formed hybrids with the native, diploid E. angustifolia. To determine viability of the native coneflower relative the introduced crosses, we measured survival and above-ground morphology of intraspecific and reciprocal interspecific crosses of E. angustifolia and E. pallida for five years. We also recorded photosynthetic rate, water use efficiency, and leaf thickness all living basal plants in 2018. E. angustifolia intraspecific crosses had the lowest survival, morphology, and ecophysiology values compared with all other cross types; E. pallida intraspecific crosses almost always had the highest values. In nearly all categories, Echinacea hybrids displayed intermediate phenotypes of pure E. angustifolia and E. pallida. These results suggest that the genomes of E. angustifolia and E. pallida combined in an additive manner when forming hybrids. With increased viability over the pure native cross type, plants with a non-native E. pallida parent may be able to harm the already-decreasing population of E. angustifolia in Douglas County, MN. Management should be undertaken to eliminate mating bouts of E. angustifolia and E. pallida. **Riley Thoen**, Stuart Wagenius, Sanjive Qazi, and Pamela Kittelson Advisor: Pamela Kittelson, Biology

Session B: Oral Presentations, Olin Hall 220	
1:30 pm	**Subglacial Mineral Erosion Rates from the Little Ice Age to Present for College Glacier** As glaciers retreat, their erosion rate changes, and therefore indicator material concentrations change. Indicator material dispersal trains from glacial covered bedrock is a much studied, but little modeled process. Many mineral exploration groups use indicator minerals to examine potential sites, but without understanding the processes by which dispersal trains form it is difficult to assess whether these sites are economically viable. Larson and Mooers developed equations in 2004 that modeled entrainment and transport of glacial indicator material and tested them on a paleoglacier. Their article has been cited 18 times, only one of which was pushback, and there has been no error analysis of their equations. This thesis attempts to determine if Larson and Mooers have established a valid technique through a sensitivity test, and apply the equations to an extant glacier. We collected till samples from College Glacier in the Alaska Range and sent them to the University of Alaska for x-ray fluorescence to determine elemental concentration. Combined with pre-established temporal data and newly created spatial data, these concentrations allowed us to employ Larson and Mooers equations for the purpose of modeling the changing erosion rate beneath College Glacier from the Little Ice Age to modern day. Our sensitivity test revealed that the equations were useful, and further found that as the glacier retreat erosion increases. This implies that with the onset of climate change, glacial sites such as this one with high heavy Rare Earth Element concentrations will erode more and distribute more heavy REEs. **Charlotte Cowdery** Advisor: Laura Triplett, Geology
1:45 pm	**Predicting Pitch Type in MLB** Pitchers strive to be unpredictable; estimating pitcher predictability is a potential way to evaluate pitching effectiveness. It will also be important to account for predictable patterns in pitching in models of at-bat outcomes, if such patterns exist. In this light, we use random forests, a tree-based classification method, to predict pitch type (e.g. four-seam fastball, curve ball, slider, etc.) using the characteristics of the previous pitch. We examine the 396 MLB pitchers who threw more than 1000 pitches over the 2015 to 2018 seasons. The data is acquired from Statcast, a service that records data, including pitch velocity, type, location, etc., from every pitch in every MLB game. We examine pitch type and 15 potential explanatory variables, including initial velocities in three dimensions, results of the pitch, and the locations where the ball left the pitcher's hand and where it crossed home plate. We specifically compare Clayton Kershaw, one of the best pitchers in the MLB and Yu Darvish, who is known for his particularly diverse arsenal of pitches. Initial results for both pitchers have prediction accuracies slightly better than a coin flip. We will further investigate the predictability of all 396 pitchers in our data set, and then comparing them to try and identify factors associated with high predictability. **Avery Wood** Advisor: Laura Boehm Vock, Mathematics, Computer Science, and Statistics
2:00 pm	**Microstructural and Rheologic Analysis of the Wildhorse Detachment Fault Zone in the Pioneer Mountains, ID** Detachment fault systems are important to understanding tectonics because they can cause kilometer-scale extension in the upper crust while syntectonically exhuming mid-crustal material. These fault systems commonly initiate in rheologically weak zones, such as metasedimentary units in the mid-to-upper crust. Strain partitioning is assessed through microstructural and rheologic analysis of differing lithologies in the

	footwall of the Wildhorse detachment fault of the Pioneer metamorphic core complex in south-central Idaho (USA). A ~350 m vertical transect in the fault zone footwall is composed of migmatitic gneiss at the base, which is overlain by interlayered marbles and granodiorite sills, and quartzites at the top of the footwall. The metasedimentary units, marbles and quartzites, show top-to-the-NW shear sense in field (i.e. m-scale shear bands) and microstructural observations (i.e. mica fish and S-C structures). Textures of the gneisses and marbles depict completely recrystallized quartz and calcite, respectively, as well as ribboning with dynamically recrystallized quartz grains in the quartzites. Crystallographic preferred orientations (CPO) of the marbles and quartzites were analyzed by scanning electron microscopy with electron backscatter diffraction (EBSD). The quartzites near the top of the fault zone show patterns of rhomb <a> slip, whereas the interlayered quartzites and marbles lower in the fault zone show either evidence of prism <a> slip or no CPO. These results indicate that the metasedimentary units within the Wildhorse detachment fault zone accomodated penetrative strain during regional extension, and therefore had strong effects on the rheology and initiation of the Wildhorse detachment fault system. **Alex Senjem** Advisor: Rory McFadden, Geology
2:15 pm	**The Influence of Landslides on Ravine Valley Morphology in Nicollet and Sibley Counties** The Minnesota River's water quality is impaired by sediment that can be traced in part to bluff erosion in ravines. Bluff erosion can happen via landslides, which are mass movements of geologic material, and also via erosion by fluvial processes. Since bluff erosion is a common characteristic of ravines, determining the role of landslides in influencing ravine shape and size is an important step toward understanding how sediment is distributed in river systems. In this research, we looked at how landslide size and frequency relate to ravine characteristics and identified the overall nature of ravines traits along the Minnesota River. To describe the role of landslides in shaping ravine morphology and in contributing sediment to the watershed, we identified past landslides on LiDAR aerial images of ravines along the Minnesota River in Nicollet and Sibley counties. The extent of each landslide was mapped using GIS (Geographic Information Systems) and ArcGIS tools were used to measure ravine and landslide features (surface area, length, frequency). The landslide density and surface area were evaluated statistically in the context of ravine size and location to see how they influence ravine valley morphology. In conclusion, the relationship between landslides and ravines along the Minnesota River will be discussed while exploring how these connections may affect water quality in the river. **Emily Fischer** Advisor: Laura Triplett, Geology
2:30 pm	**Uncertainties in Glacier Geodetic Volumetric Analysis on Volcan Chimborazo, Ecuador** Glacial melt due to climate change is occurring rapidly in the equatorial region of Ecuador on Volcan Chimborazo. Geodetic volumetric data collection contains methodological approaches that garner practical and statistical limitations in regards to fieldwork, structure from motion DEM creation, and DEM differencing. Using UAV acquired imagery on the Reschreiter glacier, the discussion of uncertainties in glacial research and the quantification of volumetric glacial loss will be presented. **Hanna Albers** Advisor: Jeff LaFrenierre, Geography

2:45 pm	**Quantifying Glacier Volume Change using an Unmanned Aerial Systems (UAS)-Derived Imagery and TanDEM-X Data on Volcán Cayambe, Ecuador.** Melting tropical glaciers are indicators and recorders of a warming climate. Assessing this change is important to understanding the future water supply in local communities. In this study we assess volume change on the Hermoso Glacier on Volcán Cayambe, Ecuador. We use data from two different sources to compare Digital Elevation Models (DEM) of the glacier surface. One source is unmanned aerial systems (UAS) derived imagery using structure from motion photogrammetry. The other source is satellite derived TanDEM-X data. We also assess sources of uncertainty with both the field collection process and DEM differencing methodologies. **Chloe Shaw**, Hanna Albers, and Jeff LaFrenierre Advisor: Jeff LaFrenierre, Geography
3:00 pm	**Tomographic Reconstruction of 2D Ultrasound Projections** The development of acoustic measurements are continually important due to their applications ranging anywhere from musical to medical. In an ongoing study of ultrasound in the Huber lab, this past summer (2018) we continued research using refracto-vibrometry, an optical measurement of sound. Using a scanning laser doppler vibrometer we imaged ultrasound fields propagating through and scattering off of objects. Much of the summer was spent further developing computer programs to tomographically reconstruct 2D wave projections in order to create tomographic videos of wave propagation. We also did a lot of work streamlining data analysis and data taking procedures in order to make research faster. **Ezekiel Haugen** Advisor: Thomas Huber, Physics
3:15 pm	**Instability and Complexity of Polycyclic Musk Galaxolide** Galaxolide (1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethylcyclopenta[γ]-2-benzopyran, or HHCB) is a member of a family of polycyclic musks used as a fragrance in many consumer products. There have been numerous reports describing detection of galaxolide in wastewater treatment plant (WWTP) effluents and surface waters. It is suspected to interfere with the MDR/MDX defenses of aquatic life, ultimately affecting their ability to protect themselves from other toxins present the environment. It is also suspected to be an endocrine disrupting compound and been labeled as a contaminant of emerging concern by the Environmental Protection Agency. Although there is a fair amount of work published on studies of the fate of galaxolide in the environment and wastewater treatment streams, in our own work we have encountered a number of difficulties that have not been reported previously, to the best of our knowledge. In this presentation we will describe the results of a number of lines of inquiry related to these peculiarities. To the best of our knowledge, a highly pure analytical standard for galaxolide is not commercially available. We will describe results of different approaches to produce highly pure galaxolide on a semi-preparative scale. We also find that different species present in commercially available galaxolide materials exhibit very different detector responses when using liquid chromatography coupled with UV absorbance or electrospray ionization mass spectrometry. Finally, we find that highly purified galaxolide is prone to rapid (timescale of minutes) transformation when exposed to water. Implications of these findings for future environmental fate studies of galaxolide will be discussed. **Amy Crawford**, Devin Makey, David Harmes, and Kristine H. Warmer, and Dwight Stoll Advisor: Dwight Stoll, Chemistry